(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 April 2002 (25.04.2002)

PCT

(10) International Publication Number
WO 02/33312 A2

(51) International Patent Classification[7]: F21V

(21) International Application Number: PCT/DK01/00688

(22) International Filing Date: 18 October 2001 (18.10.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2000 01565 19 October 2000 (19.10.2000) DK

(71) Applicant *(for all designated States except US)*: REIPUR TECHNOLOGY A/S [DK/DK]; Gentoftegade 118-120, DK-2820 Gentofte (DK).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: REIPUR, John [DK/DK]; Fabritius Allé 17, DK-2930 Klampenborg (DK).

(74) Agent: PLOUGMANN & VINGTOFT A/S; Sankt Annæ Plads 11, P.O. Box 3007, DK-1021 Copenhagen K (DK).

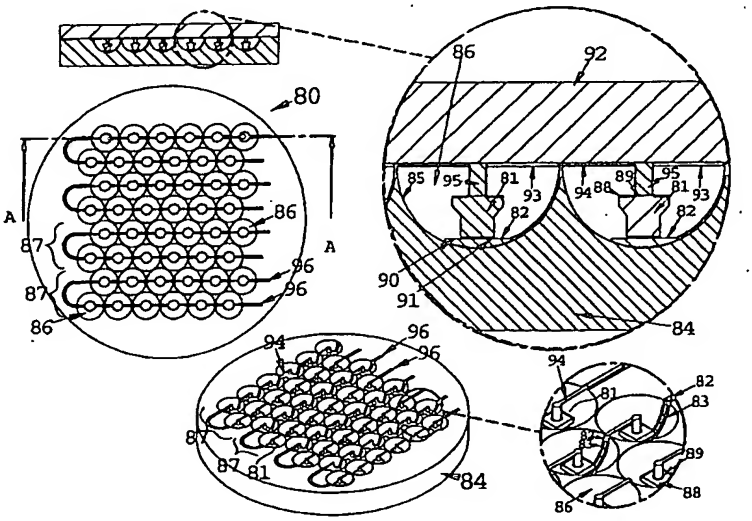
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) Title: A LIGHT-EMITTING ASSEMBLY



(57) Abstract: A light-emitting assembly (80) comprises a plurality of light-emitting diodes (81) and at least one connection conductor (82) for providing electrical connections between poles of light-emitting diodes (81). The connection conductor (82; 182) may be provided as a layer (82) on a support or holding member (84) for the diodes, or as a layer on a cover (92) covering the diodes. Power transmitting conductors for providing electrical power to the light-emitting diodes are provided. A heat conductive element connects the assembly to an external part. The assembly may be formed as a so-called pellet (10) and is intended mainly for use in instruments for hardening dental fillings, wherein there is a need for transporting heat away from a distal end of a dental instrument at which the pellet is positioned.

WO 02/33312 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A LIGHT-EMITTING ASSEMBLY

Technical field

The invention relates to improvements in lighting instruments mainly for dental use.

Description of the invention

A first aspect of the invention relates to a "pellet" which is may constitute the distal end of a light-emitting apparatus and which is to comprise the light-emitting diodes. The object of the "pellet" is to receive power from the remainder of the apparatus and for providing the light. Also, it is an object of the pellet to be adapted to withstand cleansing by autoclaving.

The basic invention relates to the fact that light-emitting diodes (LED) provide a certain amount of heat during operation, and that a close positioning thereof may damage the diodes. Consequently, in addition to providing power to the diodes it is desired to also remove heat from this diode assembly.

Oppositely, during autoclaving, the pellet will be cleansed at a pressure of several bar and at an elevated temperature of above 100 degrees Celsius which means that a high thermal conductivity from the diodes to the surroundings and vice versa will not be desired in that the autoclaving may then damage the interior of the pellet.

Consequently, a novel way of removing heat from the pellet during operation is required - a manner which nevertheless does not have a high degree of heat conductivity during autoclaving.

The first aspect of the invention relates to a light-emitting assembly comprising a number of light-emitting diodes, each of which has two poles, the diodes comprising at least a first and a second light-emitting diode, the assembly further comprising:

- at least one connection conductor for providing electrical connections between a pole of the first light-emitting diode and a pole of the second light-emitting diode,
- a number of at least two power transmitting conductors for providing electrical power to or through at least one of the light-emitting diodes, the number of power

transmitting conductors being less than or equal to the number of light-emitting diodes,

- means for attaching the assembly to an external part,
- at least one heat conductive element interconnecting the assembly and the external part, so as to allow for conductive heat transfer from the assembly to the external part.

In an embodiment of the invention the light-emitting assembly comprises a plurality of light-emitting diodes such as 2-1000 or several thousands, such as 4-800, such as 12-600, such as 24-400, such as 48-200, such as 64-160, such as 72-120, such as 24, 48, 60, 72 or 84 within an area of 0.5 - 1.5 cm^2, such as 0.7 - 1.2 cm^2, such as within a circular area with a diameter of approximately 1 cm. The diodes may be arranged over a relatively small area e.g. so that the distance between the diodes is less than 10 times the diagonal distance of one of the diodes, or less than 5 times the diagonal distance of one of the diodes or preferably less than three times the diagonal distance of one of the diodes or preferably less than two times the diagonal distance of one of the diodes.

The close arrangement of the light-emitting diodes results in a relatively high concentration of thermal energy over a small area. Thus, means for transporting the thermal energy away from the diodes is needed, so as to ensure an optimal working temperature for said diodes and thereby ensuring high efficiency of the diodes and non-damage to the diodes. Further, if the assembly forms part of an instrument for curing a dental filling, the temperature of the outer surface of the assembly must not, as prescribed by health authority regulations, exceed a temperature higher than 10°C above a surrounding temperature, i.e. it must not exceed approximately 45°C. Thus, the assembly may comprise a first heat conductive element placed as close to the diodes as possible, in which case the diodes may be attached to said first heat conductive element. The heat conductive element may be made of a material with a high thermal conductivity. Examples of thermophysical properties of the material of the heat conductive element are listed below.

Only two power transferring conductors may be connected to at least one of the diodes, e.g. in such a way that power is supplied to all the diodes in the light-emitting assembly. This facilitates mounting of the assembly e.g. to a printed circuit board.

The light-emitting diodes comprised in the invention may be shaped as cubes or any other element with at least two surfaces with poles on different surfaces of the diode, such as at opposite sides. Appropriate light emitting diodes are available from CREE, Inc., Durham, North Carolina, U.S.A., a useful diode being the CXXX-UB290-E1000 or the CXXX-UB290-E400. The light-emitting diodes may emit light having wave lengths in the interval between 100 nm and 900 nm, such as between 200 nm and 700 nm, such as between 300 nm and 500 nm, or preferably between 400 nm and 500 nm or preferably between 450 nm and 490 nm. The diodes may be light-emitting diodes such as diodes emitting 90 % of the light in an interval of 10 to 20 nm or laser diodes such as diodes emitting 90% of the light in an interval between 1 and 2 %.

For some of the embodiments the diodes are connected in series. But may also be connected in parallel or in a combination thereof. In a preferred embodiment the diodes are connected in series of diodes, such as series of 12 diodes. The series of e.g. 12 diodes may be connected in series or in parallel. In a preferred embodiment the diodes are arranged is series of 12 diodes, the series being arranged in parallel.

Also some of the diodes may have a first surface with a first electrical pole and a second surface with a second electrical pole, the first surfaces of the first and second light-emitting diodes, respectively, being supported by a holding member. Said holding member may be attached to the conductive element and/or the external part. In preferred embodiment the holding member, the conductive element and the external part may be integrated in a single element.

It is preferred that at least a part of the holding member may have a light reflecting surface for reflection of the light emitted from the diodes. Thereby the holding member can be used as a reflector, thus making it possible to direct the emitted light in a desired one direction. The part of the holding member having a light reflecting surface may be shaped as an indentation i.e. a concave surface. Said concave surface may be shaped as a rotation of an ellipsoid or a parabola. Alternatively, the concave surface may have a triangular pyramid-like shape. A plurality of indentations may be formed in the holding member by pressing or punching a pattern of spheres or other members into a plate from which the holding member is made. Alternatively, a plurality of indentations may be formed in the holding member by cutting. By shaping the holding member as an indentation it is possible to direct the light even more precisely in the desired direction.

The diameter of the indentations may be less than 5 mm, or less than 3 mm, or less than 2 mm or preferably less than 1 mm, such as 0,8 mm.

The diodes may be at least partly surrounded by one of the indentations in the surface. The diodes may be attached to the bottom of the indentations, so that at least part of each diode is surrounded by the indentation. A diode may also be attached to the sides of a indentation.

The light reflecting surface may be covered by an electrically insulating layer, so that the diodes are not electrically connected to the reflecting surface or the holding member. The complete surface may be covered by the electrically insulating layer, whereby the layer protects the surface from corrosion, whereby the surface may remain its reflecting properties.

The electrically insulating layer may be transparent so as to allow reflection from the light reflecting surface. The electrically insulating layer may also be constituted by a substantially light reflecting layer. The layer may be a quartz layer attached to the light reflecting surface be means of thermal evaporation or sputtering deposited thin films.

In another embodiment of the invention, only a part of the light reflecting surface is covered by the electrically insulating layer. Such a part may be at least a part of each indentation e.g. a bottom area of the indentation so that the diode is electrically insulated from the light reflecting surface when said diode is attached to the bottom of the indentation. Furthermore the electrically insulating layer may cover at least the area within the associated indentation to which the light-emitting element is attached and a path extending away from said area. The path may extend from said area to the edge of the indentation or substantially to the edge of the indentation, but it may also extend from said area and to a point on the side of the same indentation or another indentation.

At least one of the connection conductors and power transmitting conductors may comprise one or more wires bonded to said poles. The wires may be bonded by use of wire-bonding technology, where a thin wire e.g. made of gold is bonded between said poles. If the diodes are connected in series, a bond between two diodes is in a first end attached to an anode of one diode e.g. placed on the top of the diode and in a second end

the bond is attached to a cathode of the other diode, said cathode e.g. being placed at the bottom of the diode.

In an alternative embodiment, the majority of or at least some of the connection conductors and power transmitting conductors is constituted by an electrically conductive layer applied on at least a part of the surface of the holding member. The layer may be an electrical conducting lacquer, varnish or enamel, such as a AC43 polyester lacquer. The layer may be firmly attached to the surface of the holding member. The layer may also be applied to at least a part of the electrically insulating layer, so as to electrically insulate the conductive layer from the surface of the holding member.

The electrically conductive layer may cover at least the area within the associated indentation to which the light-emitting element is attached and a path extending away from said area. Analogously the path of the electrically conductive layer may extend from said area and to the edge of the indentation or substantially to the edge of the indentation, but may also extend from said area and to a point on the side of the indentation. By applying the electrically conductive layer it is possible to create an electrically conductive connection to the diode at different point of the indentation.

At least a part of the holding member may be covered by a substantially transparent cover, the light-emitting diodes being arranged between the cover and the holding member, the cover having a surface facing the diodes. The cover may be made of a material such as glass, quartz glass, borosilicate glass, sapphire quartz glass, sapphire glass, a transparent acrylic material, silicone or epoxy. The cover may have the function of a lens. Alternatively, a separate lens may be mounted between the diodes and the cover or at an opposite free surface of the cover.

At least part of the cover may be electrically conductive or comprises an electrically conductive material. At least a part of said material may be integrated in the cover, so as to protect the material and electrically insulate it from the surroundings. The electrically conductive material may also be applied to the surface of the cover which faces the diodes. Thereby it is possible to connect the electrical conductive layer applied in the indentation with the electrical conductive layer applied in the cover or on the surface of the cover, whereby wire connections may be avoided. The layer may be applied to the surface of the indentation and it may extend to the edge of the indentation, whereby the

electrically conductive layer of the surface of the cover may be pressed into electrical conductive contact with the electrically conductive layer applied to the indentation. In an alternative embodiment the electrical conductive connection between the layer of the indentation and the layer of the cover is constituted by a conductor, such as a wire or a solid. This may be done when the electrically conductive layer of the indentation does not extend to the edge of the indentation.

The second pole of at least one of the light-emitting diodes may be electrically connected to the electrically conductive part or material of the cover. Analogously this may be done by use of a conductor, such as a wire or a solid.

In any aspect of the present invention, any of the heat conductive elements is preferably made from a material having a thermal conductivity above 10 W/m*K, such as above 50 W/m*K, such as above 75 W/m*K, such as above 100 W/m*K, such as above 150 W/m*K, such as above 200 W/m*K, such as above 300 W/m*K, such as above 400 W/m*K, such as above 500 W/m*K at room temperature (300 K). Appropriate materials may be or may comprise Aluminum or alloys thereof, copper, bronze, brass, gold, steel, platinum, silver, or any plastic-based or plastic-comprising heat conductive material, or any carbon-based composition, comprising graphite, silicon carbide, silicon dioxide or any combinations thereof.

The heat conductive element or the external part or any further element to which the heat conductive element or the external part is mounted may have a relatively high specific heat, such as a specific heat of at least 100 J/kg*K, such as at least 200 J/kg*k, such as at least 300 J/kg*K, such as at least 350 J/kg*K, such as at least 400 J/kg*K, such as at least 450 J/kg*K, such as at least 500 J/kg*K, such as at least 550 J/kg*K, such as at least 600 J/kg*K, such as at least 650 J/kg*K, such as at least 700J/kg*K, such as at least 750 J/kg*K, such as at least 800 J/kg*K, such as at least 850 J/kg*K, such as at least 900 J/kg*K, such as at least 950 J/kg*K, such as 1000 J/kg*K or more. Appropriate materials Appropriate materials may be or may comprise Aluminum or alloys thereof, copper, bronze, brass, gold, steel, platinum, silver, or any plastic-based or plastic-comprising heat conductive material, or any carbon-based composition, comprising graphite, silicon carbide, silicon dioxide or any combinations thereof.

The assembly according to the first aspect of the invention may comprise any feature and/or functionality described below in connection with the second and third aspects of the invention.

A second aspect of the invention relates to a light-emitting assembly comprising at least a first and a second light-emitting diode, each of which has a first surface with a first electrical pole and a second surface with a second electrical pole, the first surfaces of the first and second light-emitting diodes, respectively, being supported by a holding member.

At least one connection conductor for providing electrical connections between a pole of the first light-emitting diode and a pole of the second light-emitting diode may be provided. The connection conductors may be arranged so that the diodes are connected in series, but the diodes may also be connected in parallel or in a combination of series connections and parallel connections.

Furthermore, the light-emitting assembly may comprise a number of at least two power transmitting conductors for providing electrical power through at least one of the light-emitting diodes, the number of power transmitting conductors being less than or equal to the number of light-emitting diodes. The light-emitting assembly may have only two power transmitting conductors so that mounting of the assembly to e.g. a printed circuit board is simple.

The light-emitting assembly may be adapted to be attached to an external part, e.g. in such a way that the light-emitting assembly is encapsulated, so as to protect the assembly electrically, thermally or from externally applied forces e.g. applied by accident by the user of the light-emitting assembly.

In order to convey thermal energy away from the light-emitting assembly, at least one heat conductive element interconnecting the assembly and the external part may be provided, so as to allow for conductive heat transfer from the assembly to the external part.

Furthermore the second aspect of the invention may comprise any feature and/or functionality described above in connection with the first aspect of the invention or below in connection with the third aspect of the invention. It should be noted that the diodes

used in the assembly according to the second aspect of the invention may have any shape or configuration, including those where the two poles of the diodes are arranged on a single surface.

The third aspect of the invention relates to an assembly of two attachable and detachable parts, the assembly comprising:

- a first part comprising:
  - one or more light emitters, and
  - means for receiving power and transferring the power to the light emitters, and

- a second part comprising means for providing power to the receiving means of the first part,

the first part further comprising means for transferring heat generated by the light emitter(s) to the second part, the first part being adapted to transfer at least 40 % of the heat generated by the light emitter(s) to the second part, and

the second part further comprising means for receiving heat from the transferring means of the first part.

The problem is preferably solved by removing the heat via the electrical terminals of the pellet whereby heat transferred via the electrical terminals will be transferred to the remainder of the light-emitting apparatus - an apparatus which preferably has a large thermally conducting mass, thermally communicating with the electrical terminals. In this manner, heat provided at the electrical terminals of the pellet during use will be effectively removed into the remainder of the apparatus. However, during autoclaving, the first part, the pellet, is autoclaved on its own whereby the only thermal contact between the surroundings and the interior of the pellet will be the rather small electrical contact of the pellet.

Preferably, the first part further comprises isolating means adapted to prevent or reduce heat transmitted from the light emitter(s) to an outer surface of the first part, the outer surface not comprising the heat transferring means.

Naturally, it is preferred that the first part transfers as much heat as possible, that is, at least 50%, such as at least 60%, preferably at least 70% of the heat generated by the light emitter(s) to the second part.

The first part may comprise one or more light-emitting diodes or laser diodes.

Also, it is preferred that the heat transferring means comprises a heat transferring material, such as a moulding silicone, contacting the diode(s). In this manner, heat is not only transferred via gas, electrical conductors etc.

For a number of applications, the first part should be at least substantially fluid tight, such as at least substantially fluid tight at a pressure of at least 2 bar, such as at least 2½ bar. In this manner, the first part may be cleansed by e.g. autoclaving.

In a preferred embodiment, the first part comprises a tubular part, wherein the light emitter(s) is/are positioned, and two end parts adapted to close the tubular part, wherein at least one end part of the tubular part and a circumferential part of at least one of the end parts are adapted to be wedge-shaped and corresponding so that the circumferential part is adapted to fit inside the wedge-shaped end part. In this manner, an increased external pressure will increase the sealing of the first part.

Normally, the first part comprises transparent means positioned so as to be able to transfer light from the light emitter(s) to surroundings of the first part. Such transparent means may be made of sapphire.

As mentioned above, preferably the receiving means and the heat transferring means of the first part comprise electrical connectors or conductors positioned at or on a surface of the first part and wherein the power providing means and the heat receiving means of the second part comprise electrical connectors or conductors provided at or on a surface of the second part. In that situation, the first part may comprise a cone-shaped part having at or on a surface thereof the electrical connectors or conductors of the first part and wherein the second part comprises an indentation or a hole having a shape corresponding to that of the cone-shaped part and having at or on a surface part therein the electrical connectors or conductors of the second part.

Then, the electrical connectors or conductors of the first part may have an overall surface of at the most 6mm^2, such as at the most 5mm^2, preferably at the most 4mm^2, such as at the most 3mm^2, preferably at the most 2mm^2.

Also, the cone-shaped part and the hole/indentation may comprise corresponding and engaging threads in order to provide the engageability/disengageability.

The second part may be adapted to dissipate at least part of the heat received by the heat receiving means at a surface of the second part.

Naturally, the second part should be able to receive and transport a sufficient amount of heat in order to avoid excessive heating within the first part. Preferably, the second part is adapted to receive and transport at least 1, such as at least 2, preferably at least 5, such as at least 10 Joules of energy away from the heat receiving means.

Preferably, the first and second parts are adapted to maintain, during light emission from the first part in at least 1 minute, such as at least 5 minutes, a temperature of a major outer surface of the first part of at the most 45°C, such as at the most 40°C.

Also, preferably the first part is adapted to reach an internal temperature of at the most 40 °C during autoclaving at 120 °C and at 2 bar for at least 10 minutes.

It may be desired that the second part is elongate and that the first part is adapted to be attached and detached at a position at one end of the second part. This type of structure may be interesting for use in a number of dental instruments.

In an interesting embodiment, the first part is adapted to transmit light there-through along a predetermined axis. In that situation, the second part may comprise light-emitting means adapted to emit light toward the first part and along the predetermined axis when the first and second parts are attached. Alternatively, the second part may comprise light receiving means, such as a camera, adapted to receive light transmitted through the first part and along the predetermined axis when the first and second parts are attached.

In a use in dentistry, the assembly may further comprise means for attaching the first part to a tooth. In that manner, the emitted light may be used for e.g. curing a lacquer or a filling in the tooth by the use of e.g. blue light.

Also, the assembly may comprise means for providing pressurised air and/or for providing suction to/from the tooth or its surroundings in order to e.g. obtain or retain a clean tooth.

Naturally, the third aspect also relates to a first part for use in the above assembly.

A forth aspect of the invention relates to a close packing of light-emitting diodes.

Normally, light-emitting diodes have two legs where one is connected to the actual wafer and normally also a reflector. These legs normally transport the majority of the heat from the light-emitting area and to the connected electronics.

Thus, the fourth aspect relates to a light-emitting means comprising a number of light-emitting diodes or laser diodes, each diode comprising a light-emitting part and at least a first and a second electrical conductor, wherein

- part of the diodes having a first conductor having a length being 2mm or longer than the second electrical conductor,
- the first conductor of one or more of the part of the diodes being electrically connected to a second conductor of one or more of the part of the diodes,
- the number of diodes being connected to a power supply via electrical conductors different from the second electrical conductors of the part of the diodes.

Consequently, due to the fact that legs actually require a lot of space, the invention relates to actually providing diodes having specific leg constructions or cutting away most of one of the legs and connecting this to an adjacent LED or laser diode (normally using an electrically conducting glue) in order to reduce the number of legs in the combination.

The first conductors of the part of the diodes may each be electrically connected to the light-emitting part of the part of the diodes.

Also, for each of the part of the diodes, the light-emitting part may be enclosed in a containing means and wherein the second conductors extend 3mm or less, such as 2 mm or less, such as 1½ mm or less, away from the containing means. This containing means is normally made by a transparent, optionally coloured, plastic material.

In that situation, the containing means may have an outer dimension of 2 mm or less, such as 1½ mm or less, such as an outer dimension extending only 1 mm, such as ½ mm above an outer dimension of the light-emitting part of the diode. This light-emitting part may be the actual chip or wafer - or it may be e.g. a reflector built-in in the diode.

A fifth aspect of the invention relates to an instrument for optically curing a dental filling, the instrument comprising:

- means for providing a light beam for curing the dental filling, the light beam being provided along a predetermined axis,
- means for positioning at a distance from the dental filling and for reflecting or refracting the curing light beam toward the dental filling

In the present context, the distance from the filling will be any distance large enough for e.g. a dentist to see a light spot on the tooth. This distance may be 1, 2, 4, 5, 6, 10 mm or more.

In this manner, the physical extent of the light provider and of that an area (of the tooth) to be cured do not have to correspond to each other. A problem otherwise encountered is that the light provider may be too wide for the tooth, have the wrong shape or be too small for the area to be cured. All these size incompatibilities may result in a non-optimal curing.

The reflecting or refracting means may comprise a mirror positioned on the predetermined axis.

The reflecting/refracting may be made to compensate (such as to be deformable) in order to alter characteristics of the reflected or refracted light beam - such as in order to obtain any size and/or shape on the tooth. In fact, the mirror may be made adjustable in order for it to adjust the light spot provided on the tooth to the area to be cured.

The light providing means may be adapted to provide light of a plurality of wavelengths or within a plurality of wavelength intervals. Such different wavelengths may be used for curing different materials, such as plastics fillings or lacquers and for use in e.g. viewing the tooth or plastic filling. A number of manners exist in which light of different wavelengths may be provided on the tooth using LED-based lamps.

Also, the instrument may comprise means for receiving light from the dental filling and reflected or refracted by the reflecting or refracting means. In that situation, the receiving means may be camera means for providing an image relating to the dental filling to an operator.

Thus, as an adjustment may be made fully controllable if viewing light (such as white light) and e.g. a camera may be used in order for the dentist to adapt the size of the light spot on the tooth top the area to be cured.

Also, this assembly may be provided with an output providing air for drying the tooth and/or suction for removing spit from the surroundings of the tooth. In addition, means may be provided for actually providing e.g. a lacquer or the dental filling to the tooth.

In the following, a number of different embodiments of the aspects of the invention will be described in relation to light-emitting apparatus and in particular instruments for providing light for curing plastic material in dental fillings. In the drawings:

- Fig. 1 illustrates a cross-section of a preferred first part according to the third aspect of the invention
- Fig. 2 illustrates different LED assemblies for use in the part of Fig. 1
- Fig. 3 illustrates a method of compacting LED's
- Fig. 4 illustrates the use of a first part as that of Fig. 1 in a holder for attachment to a tooth,
- Fig. 5 illustrates a preferred light-emitting apparatus according to the fifth aspect - incorporating a mirror,
- Fig. 6 illustrates a preferred embodiment of the light-emitting assembly according to the first aspect of the invention,
- Fig. 7 illustrates an alternative embodiment of the light-emitting assembly according to the first aspect,

- Fig. 8 shows a light-emitting assembly mounted in a reflector,
- Fig. 9 illustrates a distal end of an instrument for curing dental filling with a light-emitting assembly, and
- Figs. 10-12 illustrate an instrument for curing dental filling with a light-emitting assembly.

Figure 1 illustrates a cross section of the preferred first part 10, or pellet, relating to the third aspect of the invention.

The actual build of the pellet 10 is an outer cylindrical casing 12 made of steel, typically used for syringe needles, a sapphire front window 14 as well as a "back piece" 16 comprising the electrical contacts 18 in a cone-shaped part 20. Preferably, the sapphire window 14 and the corresponding end of the cylindrical syringe-steel tube 12 is wedge-shaped in order for an increased pressure to force the window 14 into the wedge of the tube 12 and thereby increase the sealing thereof. Between the tube 12 and the window 14, a sealing silicone material (not illustrated) is provided.

A similar wedge-shaped set-up is used at the back end of the pellet 10. Naturally, this cone-shaped or wedge shaped part 20 may be made to have any number of electrical/thermal connections 18. Also, the part 20 comprises a threading for attaching to a corresponding threaded hole or indentation in a second part.

Within the tube 12, an electrical/thermal isolation layer 22 is provided in order to increase the isolation between the interior and the exterior of the pellet10.

Within the pellet, a number LED's or laser diodes 26 are provided, and the individual legs 28 thereof are connected (see below) to the electrical terminals 18 at the back end 16. In between the individual diodes 26, a thermally conducting moulding silicone 30 is provided in order to provide thermal cooling at the diodes 26.

Also, a layer of optically clear silicone 24 is provided in the space between the window 14 and the diodes 26.

Preferably, the diodes 26 are of a type which (or maybe manufactured to be) is very compact and preferably comprises almost only the legs and the reflector /light-emitting part thereof (see figs 2 and 3).

As to the electrical contacts 18 of the pellet 10, these are provided as a single cone-shaped element 20 having two electrically conducting bands 18 which are electrically connected to the individual LED's 26 and which are also thermally connected to the thermally conducting moulding silicone 30 within the pellet 10. The inclination of this wedged shape is preferably of a nature which makes it possible for the wedge to comprise a threading 32 for directly screwing/attaching into the second part of the apparatus for providing both an electrical and a thermal connection with corresponding connectors thereof.

Preferably, the pellet 10 is at least substantially solid (void of gas) in order for it to withstand the increased pressure during autoclaving.

The internal electrical connection of the individual LED's 26 may be a serial/parallel connection and individual legs of the LED's 26 may be connected using electrical heat fins, such as heat fins 34 having corresponding curve-linear shapes in order for heat transported via the legs of the LED's to be effectively transferred to the thermally conducting moulding silicone 30.

A corresponding second part 36 for attaching to the pellet 10 of Fig. 1 will have a hole/indentation 37 corresponding to that of the wedge-shaped conductor part 20 of the pellet 10. Internal sides 38 of the hole/indentation 37 will have electrical conductors 40 corresponding to those of the part 20 which are connected to a power supply - but the conductors 40 are additionally thermally connected to a rather large thermal mass 42, which may be the conductors 40 themselves or any similar conducting (such as electrically isolating) material, in order to remove the heat from the LED's 26. This heat may be transported to a surface 44 of the second part 36 in order for it to be dissipated there.

Fig. 2 illustrates different LED set-ups for use within the pellet 10 of Fig. 1, the circle illustrating the number of LED's 26 obtainable within a 9 mm internal diameter of the pellet 10.

A number of additions/improvements may be made using this pellet 10:

A number of different LED (26) designs may be used such as standard 3 mm LED's having a reflector, small rectangular LED's also having a reflector, or the LED's described later on in relation to Fig. 3.

Also, LED's 26 not having a reflector may be used, preferably a combination with a lens (not illustrated).

Also, the centre of the pellet 10 (from the window 14 through the cone-shaped connector 20 - as illustrated in broken lines 41) may be custom-made with one or more optical fibres or simply a transparent path for e.g. transporting specific light generated somewhere else through the pellet 10 or for transporting light from the window 14 to e.g. a camera - where the camera may be positioned in the second part of the apparatus or actually in the pellet 10 - as illustrated at 42.

Also, the pellet 10 may be comprise LED's 26 of different colours such as blue LED's for curing and white LED's for viewing (such as when using the camera).

One interesting manner of using the pellet 10 is to attach the pellet 10 to a bracket or a holder 50 (See Fig. 4) for fixing the pellet 10 to a tooth 52. This holder 50, naturally, will have a whole corresponding to the electrical conducting wedge 20 of the pellet 10 and will be adapted to receive and dissipate the heat provided in the pellet 10 during the operation.

The bracket or holder 50 may additional be provided with a tube 60 (as illustrated in Fig. 5) for providing suction for removing spit during operation and/or an outlet 62 for pressurised air for drying and cleansing the tooth 52.

Naturally, a large number of such assemblies may be used within a mouth at the same time.

Fig. 3 illustrates a compact assembly of light-emitting diodes or laser diodes according to

the forth aspect of the invention. This type of assembly may be used within e.g. the pellet 10 of the third aspect or in another light-providing apparatus.

Fig. 3 illustrates the manner in which a severed leg of one LED is electrically conducted to a longer leg of an adjacent LED. Without this manner of interconnecting the LED's, all legs must be electrically contacted whereby a larger space is required. Thus, fewer LED's can be assembled within a given area. It is seen that now only about half the number of legs need electrical connection (and even fewer may be obtained) so that the diodes 26 can be compacted so that the diameter of the reflectors 46 actually defines the minimum obtainable extension in one dimension and that the actual electrode/leg structure of the LED's defines the minimum extension in the other dimension. Also, the maximum number of LED's within a 9-mm diameter is illustrated.

Figs. 4 and 5 relate to an assembly according to the fifth aspect of the invention which is directed to avoiding e.g. a problem encountered when attempting to cure a plastic filling or a lacquer on a tooth - the problem of ensuring curing of the full area in a sufficiently efficient manner.

In this aspect, obtaining an optimum curing is obtained by providing a light-emitting part 54, such as an assembly or a first part according to the third aspect and a mirror 56 and having the curing light from the part 54 reflect off the mirror 56 toward the tooth 52.

In this manner, the physical extent of the light provider 54 and of that the area (of the tooth 52) to be cured do not have to correspond to each other. A problem otherwise encountered is that the light provider 54 may be too wide for the tooth 52, have the wrong shape or be too small for the area to be cured. All these size incompatibilities may result in a non-optimal curing.

In the preferred embodiment, the mirror 56 is adapted to alter the shape of the reflecting surface, such as by using piezo-electric transducers. In this manner, the mirror is able to compensate for any difference in size and/or shape between the part 54 and the tooth 52 or the part thereof to be cured. In fact, the mirror 56 may be made adjustable in order for it to adjust the light spot provided on the tooth 52 to the area to be cured. In fact, as an adjustment may be made fully controllable if viewing light (such as white light) and e.g. a camera (see Fig. 1) is used in order for the dentist to adapt the size of the light spot on the

tooth, an area of which is to be cured. A number of manners exist in which light of different wavelengths may be provided on the tooth using LED-based lamps in order to not have to view the tooth in the blue light usually used for curing.

Also, this assembly may be provided with an output 62 providing air for drying the tooth 52 and/or suction 60 for removing spit from the surroundings of the tooth 52. In addition, means may be provided for actually providing e.g. a lacquer to the tooth 52.

An advantage seen when the dentist can monitor the operation is that he may ensure that the tooth 52 is dry and clean before providing the lacquer and he may then subsequently immediately initiate the curing before any contamination, spit, etc. can reach the tooth 52 or the filling or lacquer to be cured.

Figure 6 illustrates a preferred embodiment of the first aspect of the invention. A light-emitting assembly 80 comprises 48 diodes 81 attached to the electrically conducting layer 82. The layer 82 is applied on an electrically insulating layer 83, whereby the layer 82 is electrically insulated from the holding member 84. The electrically insulating layer 83 is only applied on a part of the surface 85 of the holding member 84. In this embodiment the heat conductive element and the external part is integrated in the holding member 84.

The surface 85 is a substantially light reflecting surface, thus reflecting light emitted from the diodes 81. The electrically insulating layer 83 may be a transparent layer or a substantially light reflecting layer. Indentations 86 are applied to the surface 85 of the holding member 84. The diodes 81 are attached to the bottom of said indentations 86, whereby the indentations serve as reflectors, preferably parabolic reflectors.

The diodes 81 are connected in series 87 of 12 diodes 81. The embodiment comprises four series 87. Each diode 81 has a first surface 90 with a first pole 91 and a second surface 88 with a second pole 89.

In the embodiment the holding member 84 is covered by a substantially transparent cover 92, having a surface 93 facing the diodes 81. The surface 93 is provided with electrically conducting layers 94 connected to the second pole 89 of the diode 81 via a solid 95. The conductive layers 94 and 82 are pressed together in electrically conducting connection.

The connecting conductors comprise the layers 94 and 82 and the solid 95. The diodes 81 are supplied with power via the power transmitting conductors 96.

Fig. 7 shows an alternative embodiment of the assembly of the first aspect of the invention, wherein the connecting conductors comprise wire 182. The wires are fastened to the first and second poles 91, 89. A transparent cover 92 may be mounted on top of the of the holding member 84, as illustrated in figure 6.

Fig. 8 shows a light-emitting assembly 80 mounted in a reflector 101 with a lens 102.

Fig. 9 illustrates a distal end of an instrument 103 for curing dental filling with a light-emitting assembly 80. The light emitting assembly comprises a reflector 104, an isolator 105, a circuit 106 forming the connecting conductors, a number of light emitting diodes 81, and a housing 107.

Figs. 10-12 illustrate an instrument 103 for curing dental filling with a light-emitting assembly 80, see Fig. 8. The instrument 103 has a heat conductive element 108 mounted to or being integrated with the holding member of the light-emitting assembly. The heat conductive element 108 is mounted to or integral with a set 109 of structural members comprising one or more rod-shaped elements comprising one or more co-axial metallic tubes, some of which may serve as electrical conductors, and/or as heat conductors. Such a set is disclosed in detail in WO 99/49476, which is hereby incorporated in its entirety by reference, or in PCT/DK01/00266, which is hereby incorporated in its entirety by reference. Fig. 11 shows a female connector 110 into which the set 109 of structural members may be mounted, the female connector 110 being comprised in an instrument part 111. As illustrated in Fig. 12, which is an exploded view of the instrument 103, the set 109 of structural elements is connected to the instrument part 111 which may be connected to a battery pack 112.

In general, products embodying the different aspects of the invention may be provided so as to provide a light beam having any desired shape. This may be desired when curing fillings or lacquer formed as a T or an H - such as when sealing fissures of children's teeth.

Also, these products may be made to have any light intensity distribution over the cross section of the light beam, such as to concentrate light in the intersections of the T and H - or to simply have an even intensity distribution over the light beam. A problem encountered in known curing light apparatus is that the light intensity over the light beam varies by e.g. a factor of 2 whereby a filling is less completely cured in some areas compared to other areas.

CLAIMS

1. A light-emitting assembly comprising a number of light-emitting diodes, each of which has two poles, the diodes comprising at least a first and a second light-emitting diode, the assembly further comprising:

- at least one connection conductor for providing electrical connections between a pole of the first light-emitting diode and a pole of the second light-emitting diode,
- a number of at least two power transmitting conductors for providing electrical power to at least one of the light-emitting diodes, the number of power transmitting conductors being less than or equal to the number of light-emitting diodes,
- means for attaching the assembly to an external part,
- at least one heat conductive element interconnecting the assembly and the external part, so as to allow for conductive heat transfer from the assembly to the external part.

2. A light-emitting assembly according to claim 1, wherein the diodes are connected in series, in parallel or in a combination thereof.

3. A light-emitting assembly according to claim 1 or 2, where in the diodes are connected in at least one series of diodes.

4. A light-emitting assembly according to any of the preceding claims, wherein each series of diodes comprises 12 diodes.

5. A light-emitting assembly according to any of the preceding claims, wherein each of the light-emitting diodes has a first surface with a first electrical pole and a second surface with a second electrical pole, the first surfaces of the first and second light-emitting diodes, respectively, being supported by a holding member.

6. A light-emitting assembly according to any of claims 1-5, wherein the holding member is attached to the conductive element and/or the external part.

7. A light-emitting assembly according to any of claims 5-6, wherein the holding member has a substantially light reflecting surface.

8. A light-emitting assembly according to any of claims 5-7, wherein the surface of the holding member is shaped so as to form at least one indentation for reflection of light emitted from the light-emitting elements, each indentation forming said light reflecting surface as a substantially concave surface.

9. A light-emitting assembly according to claim 8, wherein at least a part of at least one of the light-emitting elements is partly surrounded by one of the indentations in the surface.

10. A light-emitting assembly according to any of claims 7-9, wherein at least a part the light reflecting surface is covered by a electrically insulating layer.

11. A light-emitting assembly according to any of claims 8-10, wherein at least a part of each of the indentations is covered with the electrically insulating layer.

12. A light-emitting assembly according to any of claims 8-11, wherein the each of the light-emitting elements are attached to the surface of one of the indentations.

13. A light-emitting assembly according to any of claims 10-12, wherein the electrically insulating layer covers at least the area within the associated indentation to which the light-emitting element is attached.

14. A light-emitting assembly according to any of claims 13, wherein the electrically insulating layer covers at least a path extending away from said area. [Beskrivelse: til border of indentation eller kun noget af vej, jf. SFO's "opfindelse"]

15. A light-emitting assembly according to any of claims 10-14, wherein the electrically insulating layer is transparent.

16. A light-emitting assembly according to any of claims 10-14, wherein the electrically insulating layer is a substantially light reflecting layer.

17. A light-emitting assembly according to any of claims 10-16, wherein the material of electrically insulating layer is a quartz.

18. A light-emitting assembly according to any of the preceding claims, wherein at least one of the connection conductors and power transmitting conductors comprises one or more wires bonded to said poles.

19. A light-emitting assembly according to any of the preceding claims, wherein at least part of at least one of the connection conductors and power transmitting conductors is constituted by an electrically conductive layer applied on at least a part of the surface of the holding member.

20. A light-emitting assembly according to claim 19, wherein the electrically conductive layer is applied to at least a part of the electrically insulating layer, so as to electrically insulate the conductive layer from the surface of the holding member.

21. A light-emitting assembly according to claim 19 or 20, wherein the electrically conductive layer is firmly attached to the surface of the holding member.

22. A light-emitting assembly according to any of claims 5-21, wherein at least a part of the holding member is covered by a substantially transparent cover, the light-emitting diodes being arranged between the cover and the holding member, the cover having a surface facing the diodes.

23. A light-emitting assembly according to claim 22, wherein at least part of the cover is electrically conductive or comprises an electrically conductive material.

24. A light-emitting assembly according to claim 23, wherein the a layer of the electrically conductive material is applied to the surface of the cover which faces the diodes.

25. A light-emitting assembly according to claim 23 or 24, wherein the second pole of at least one of the light-emitting diodes is electrically connected to the electrically conductive part or material of the cover.

26. A light-emitting assembly according to any of the preceding claims, wherein the heat conductive element is made of a material having a thermal conductivity above 10 W/m*K, such as above 50 W/m*K, such as above 75 W/m*K, such as above 100 W/m*K, such as

above 150 W/m*K, such as above 200 W/m*K, such as above 300 W/m*K, such as above 400 W/m*K, such as above 500 W/m*K.

27. A light-emitting assembly comprising at least a first and a second light-emitting diode, each of which has a first surface with a first electrical pole and a second surface with a second electrical pole, the first surfaces of the first and second light-emitting diodes, respectively, being supported by a holding member.

28. A light-emitting assembly according to claim 27, further comprising:

- at least one connection conductor for providing electrical connections between a pole of the first light-emitting diode and a pole of the second light-emitting diode,
- a number of at least two power transmitting conductors for providing electrical power through at least one of the light-emitting diodes, the number of power transmitting conductors being less than or equal to the number of light-emitting diodes,
- means for attaching the assembly to an external part,
- at least one heat conductive element interconnecting the assembly and the external part, so as to allow for conductive heat transfer from the assembly to the external part.

29. A light assembly according to claim 27 or 28, further comprising the features of any of the claims 6-26.

30. An assembly of two attachable and detachable parts, the assembly comprising:

- a first part comprising:
  - one or more light emitters, and
  - means for receiving power and transferring the power to the light emitters, and

- a second part comprising means for providing power to the receiving means of the first part,

the first part further comprising means for transferring heat generated by the light emitter(s) to the second part, the first part being adapted to transfer at least 40 % of the heat generated by the light emitter(s) to the second part, and

the second part further comprising means for receiving heat from the transferring means of the first part.

31. An assembly according to claim 30, wherein the first part further comprises isolating means adapted to prevent or reduce heat transmitted from the light emitter(s) to an outer surface of the first part, the outer surface not comprising the heat transferring means.

32. An assembly according to any of the preceding claims, wherein the first part is adapted to transfer at least 50%, such as at least 60%, preferably at least 70% of the heat generated by the light emitter(s) to the second part.

33. An assembly according to any of the preceding claims, wherein the first part comprises one or more light-emitting diodes or laser diodes.

34. An assembly according to any of the preceding claims, wherein the heat transferring means comprises a heat transferring material, such as a moulding silicone, contacting the diode(s).

35. An assembly according to any of the preceding claims, wherein the first part is at least substantially fluid tight.

36. An assembly according to claim 35, wherein the first part is at least substantially fluid tight at a pressure of at least 2 bar, such as at least 2½ bar.

37. An assembly according to any of the preceding claims, wherein the first part comprises a tubular part, wherein the light emitter(s) is/are positioned, and two end parts adapted to close the tubular part, wherein at least one end part of the tubular part and a circumferential part of at least one of the end parts are adapted to be wedge-shaped and corresponding so that the circumferential part is adapted to fit inside the wedge-shaped end part. (øget tryk giver øget forsejling)

38. An assembly according to any of the preceding claims, wherein the first part comprises transparent means positioned so as to be able to transfer light from the light emitter(s) to surroundings of the first part.

39. An assembly according to claim 38, wherein the transparent means are made of sapphire.

40. An assembly according to any of the preceding claims, wherein the receiving means and the heat transferring means of the first part comprise electrical connectors or conductors positioned at or on a surface of the first part and wherein the power providing means and the heat receiving means of the second part comprise electrical connectors or conductors provided at or on a surface of the second part.

41. An assembly according to claim 40, wherein the first part comprises a cone-shaped part having at or on a surface thereof the electrical connectors or conductors of the first part and wherein the second part comprises an indentation or a hole having a shape corresponding to that of the cone-shaped part and having at or on a surface part therein the electrical connectors or conductors of the second part.

42. An assembly according to claim 41, wherein the electrical connectors or conductors of the first part have an overall surface of at the most $6mm^2$, such as at the most $5mm^2$, preferably at the most $4mm^2$, such as at the most $3mm^2$, preferably at the most $2mm^2$.

43. An assembly according to claim 41 or 42, wherein the cone-shaped part and the hole/indentation comprise corresponding and engaging threads.

44. An assembly according to any of the preceding claims, wherein the second part is adapted to dissipate at least part of the heat received by the heat receiving means at a surface of the second part.

45. An assembly according to any of the preceding claims, wherein the second part is adapted to receive and transport at least 1, such as at least 2, preferably at least 5, such as at least 10 Joules of energy away from the heat receiving means.

46. An assembly according to any of the preceding claims, wherein the second part is elongate and wherein the first part is adapted to be attached and detached at a position at one end of the second part.

47. An assembly according to any of the preceding claims, wherein the first and second parts are adapted to maintain, during light emission from the first part in at least 1 minute, such as at least 5 minutes, a temperature of a major outer surface of the first part of at the most 45°C, such as at the most 40°C.

48. An assembly according to any of the preceding claims, wherein the first part is adapted to reach an internal temperature of at most 40 °C during autoclaving at 120 °C and at 2 bar for at least 10 minutes.

49. An assembly according to any of the preceding claims, wherein the first part is adapted to transmit light there-through along a predetermined axis.

50. An assembly according to claim 49, wherein the second part comprises light-emitting means adapted to emit light toward the first part and along the predetermined axis when the first and second parts are attached.

51. An assembly according to claim 49, wherein the second part comprises light receiving means, such as a camera, adapted to receive light transmitted through the first part and along the predetermined axis when the first and second parts are attached.

52. An assembly according to any of the preceding claims, further comprising means for attaching the first part to a tooth.

53. An assembly according to claim 52, further comprising means for providing pressurised air and/or for providing suction to/from the tooth or its surroundings.

54. A first part for use in the assembly according to any of the preceding claims.

55. A light-emitting means comprising a number of light-emitting diodes or laser diodes, each diode comprising a light-emitting part and at least a first and a second electrical conductor, wherein

- part of the diodes having a first conductor having a length being 2mm or longer than the second electrical conductor,

- the first conductor of one or more of the part of the diodes being electrically connected to a second conductor of one or more of the part of the diodes,
- the number of diodes being connected to a power supply via electrical conductors different from the second electrical conductors of the part of the diodes.

56. A light-emitting means according to claim 55, wherein the first conductors of the part of the diodes each are electrically connected to the light-emitting part of the part of the diodes.

57. A light-emitting means according to claim 55 or claim 56, wherein, for each of the part of the diodes, the light-emitting part is enclosed in a containing means and wherein the second conductors extend 3mm or less, such as 2 mm or less, such as 1½ mm or less, away from the containing means.

58. A light-emitting means according to claim 57, wherein the containing means has an outer dimension of 2 mm or less, such as 1½ mm or less, such as an outer dimension extending only 1 mm, such as ½ mm above an outer dimension of the light-emitting part of the diode.

59. An instrument for optically curing a dental filling, the instrument comprising:

- means for providing a light beam for curing the dental filling, the light beam being provided along a predetermined axis,
- means for positioning at a distance from the dental filling and for reflecting or refracting the curing light beam toward the dental filling

60. An instrument according to claim 59, wherein the reflecting or refracting means comprises a mirror positioned on the predetermined axis.

61. An instrument according to claim 59 or 60, wherein the reflecting or refracting means comprises a reflecting or refracting surface or part which is deformable in order to alter characteristics of the reflected or refracted light beam.

62. An instrument according to any of claims 59-61, wherein the light providing means are adapted to provide light of a plurality of wavelengths or within a plurality of wavelength intervals.

63. An instrument according to any of claims 59-62, further comprising means for receiving light from the dental filling and reflected or refracted by the reflecting or refracting means.

64. An instrument according to claim 63, wherein the receiving means are camera means for providing an image relating to the dental filling to an operator.

65. An instrument according to any of claims 59-64, further comprising means for providing pressurised air and/or for providing suction to/from the dental filling or its surroundings.

66. An instrument according to any of claims 59-65, further comprising means for providing the dental filling to a predetermined area or part of a tooth.

67. An instrument for optically curing a dental filling, comprising a light-emitting assembly according to any of claims 1-29.

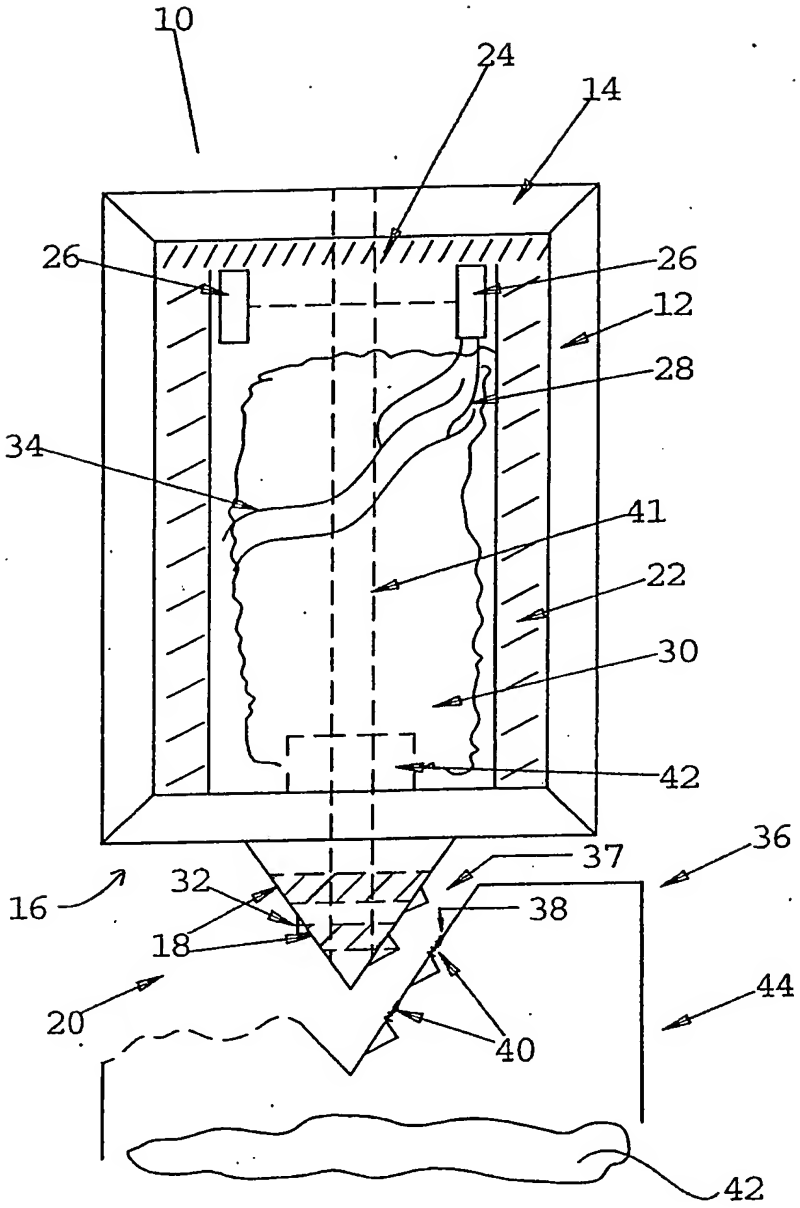


Fig. 1

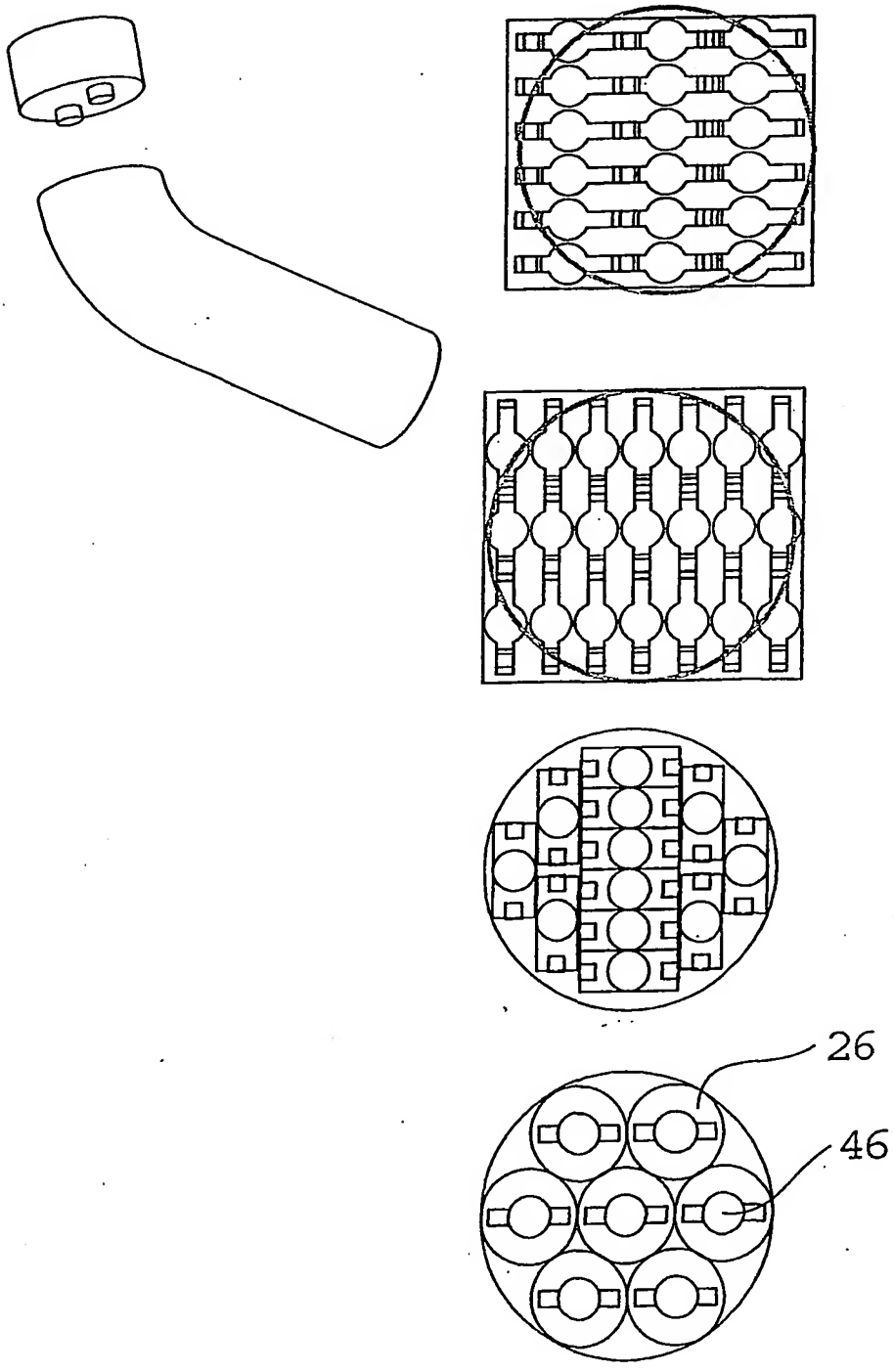


Fig. 2

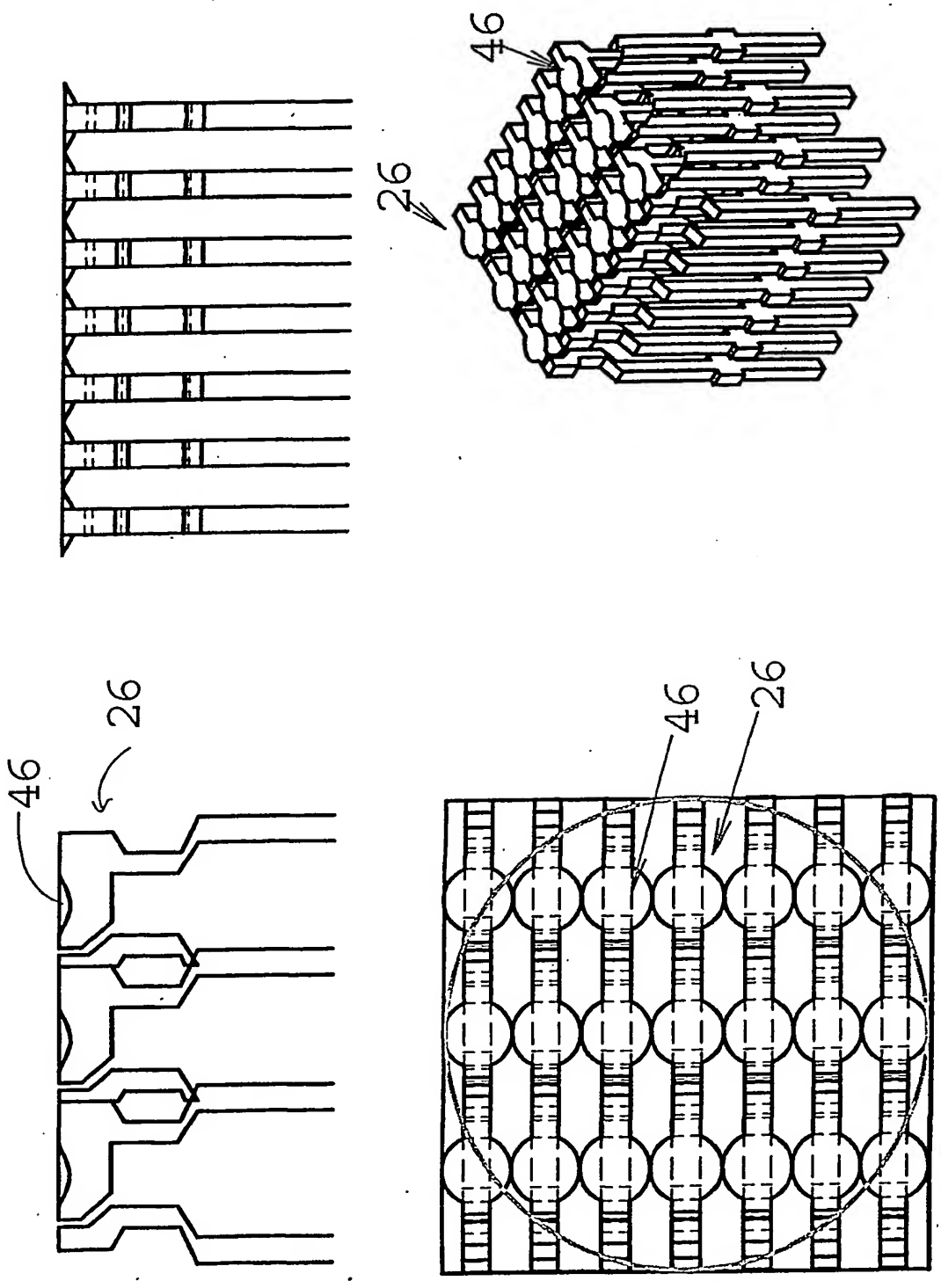


Fig. 3

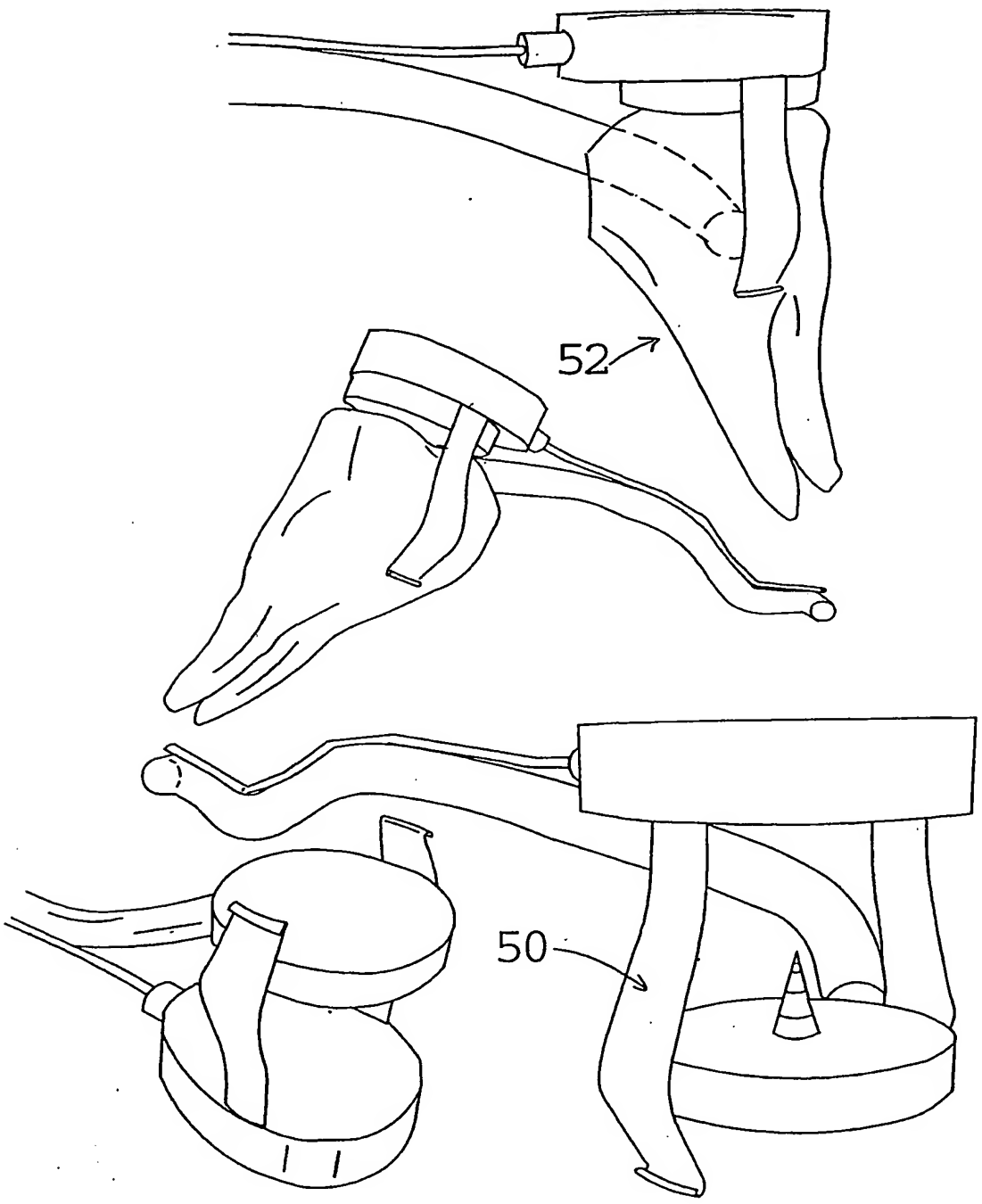


Fig. 4

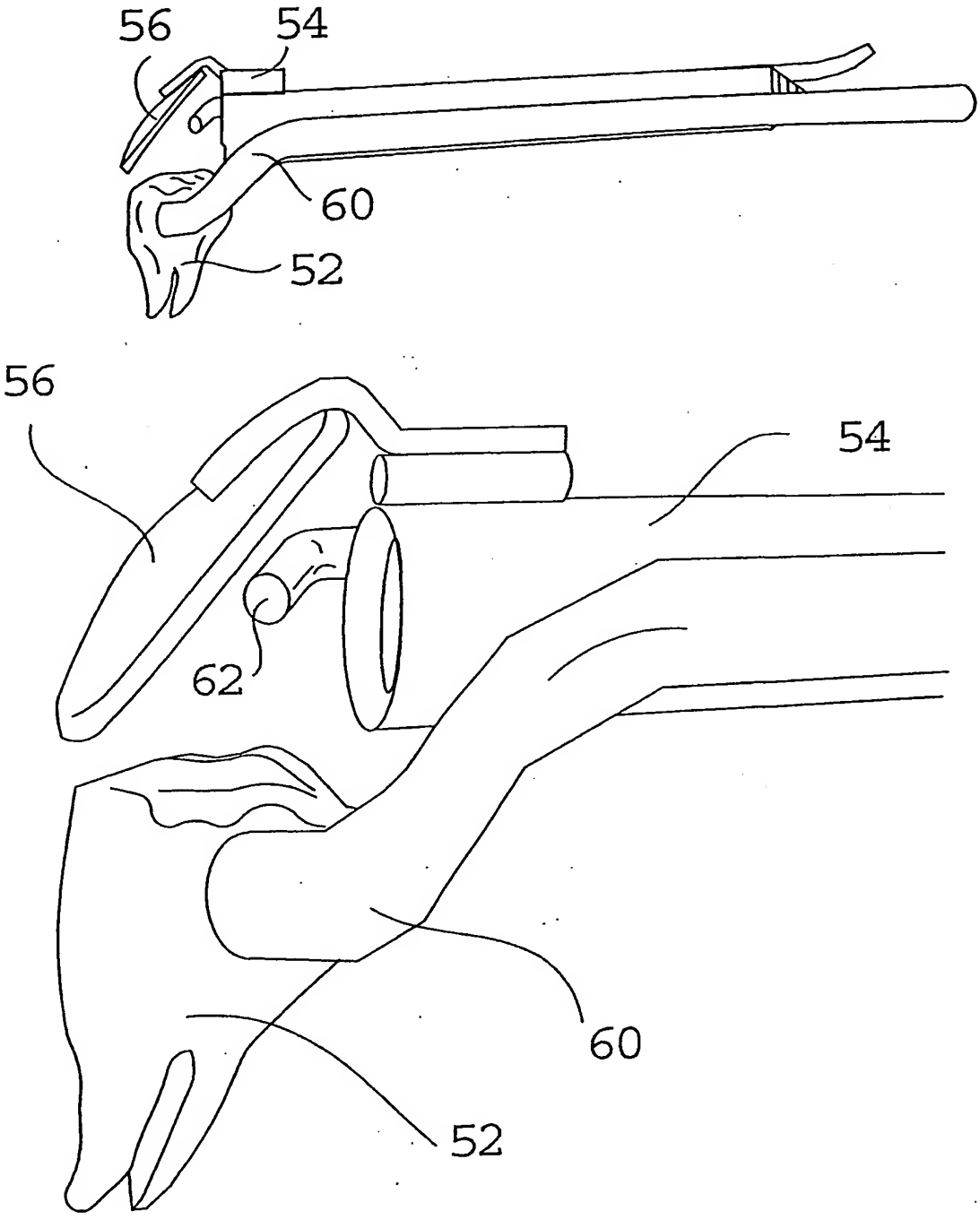


Fig. 5

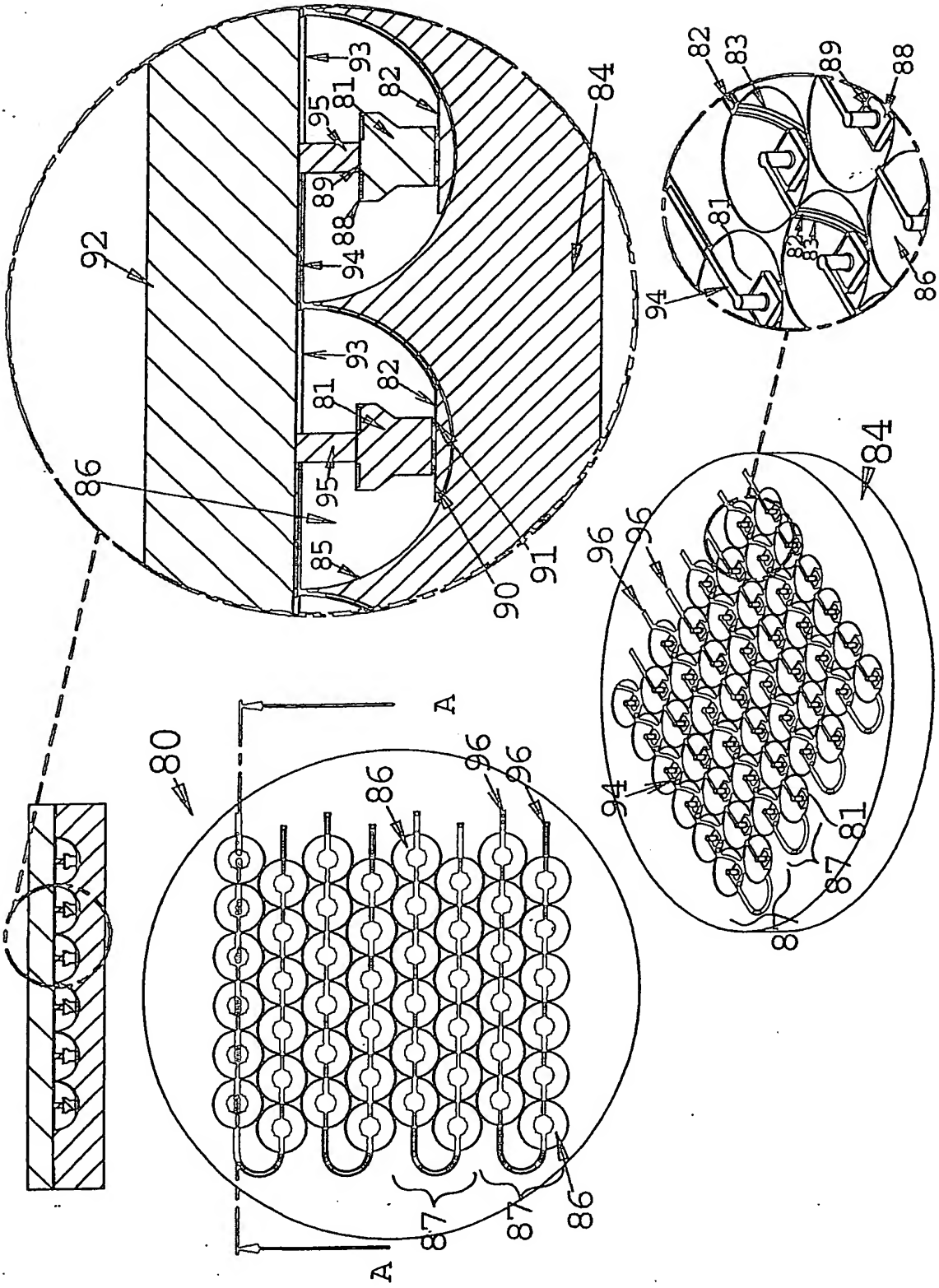


Fig. 6

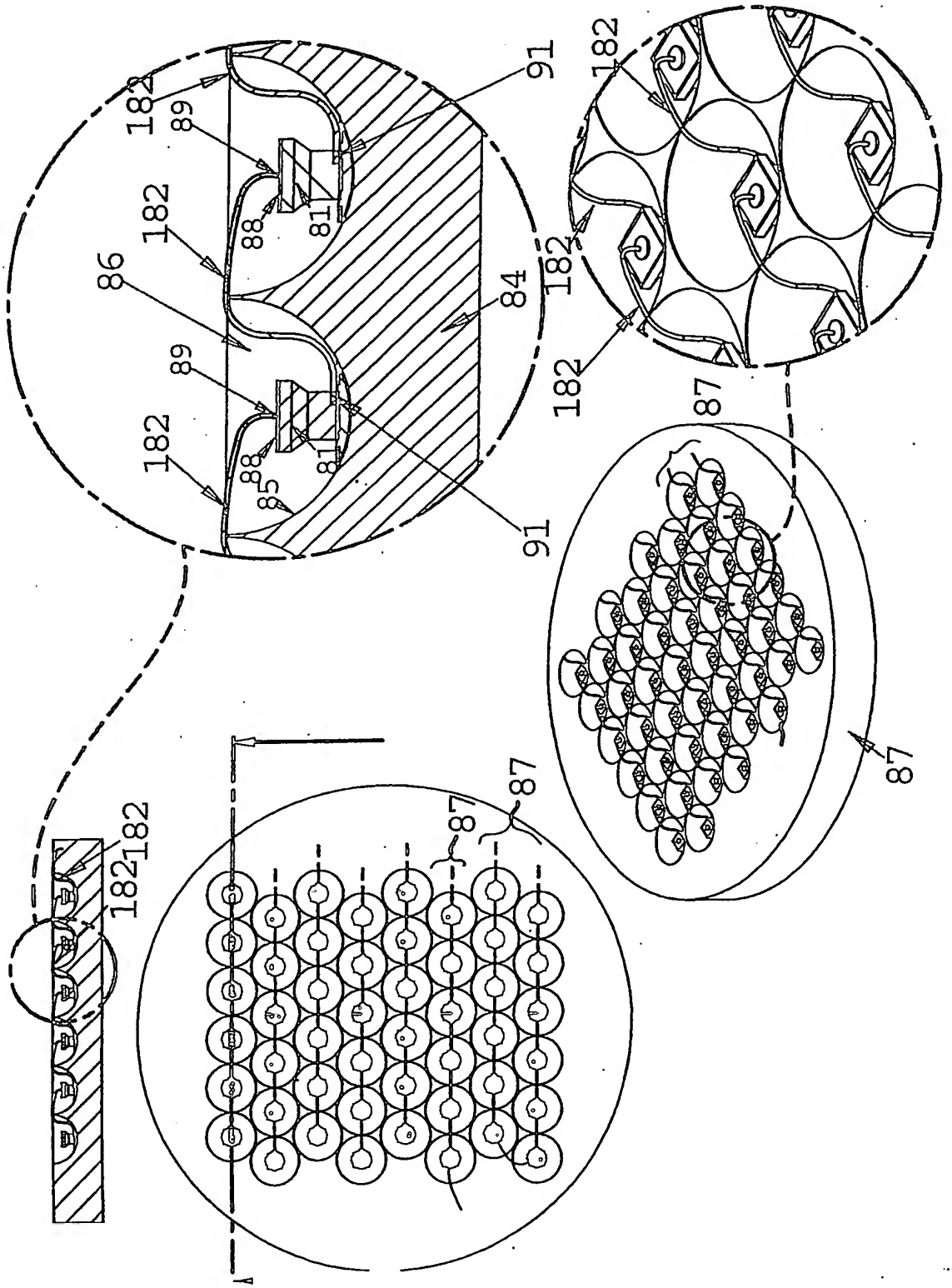

182
89
91
182
88
81
182
86
84
89
182
88
85
81
91
182
182
182
87
87
87
87
182
182

Fig. 7

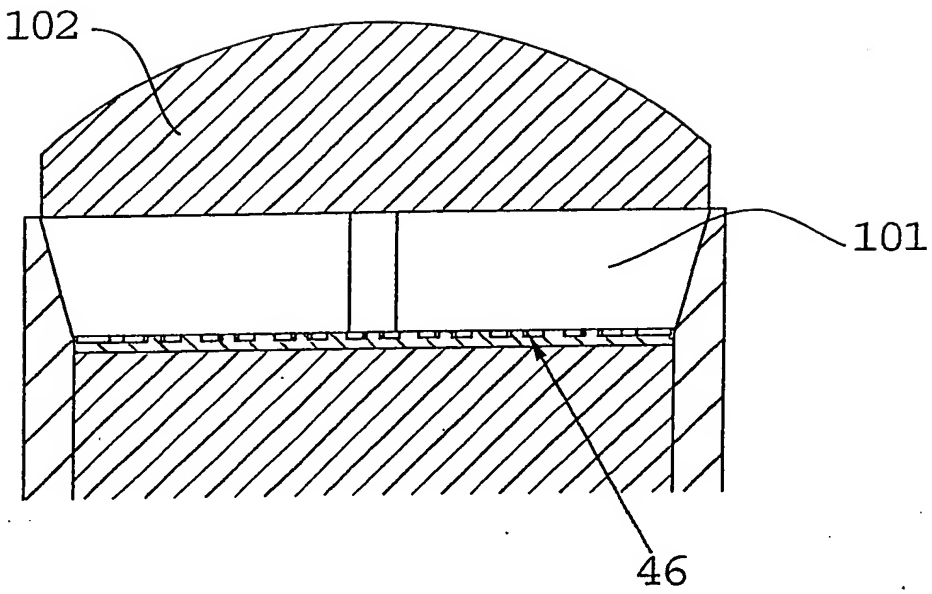


Fig. 8

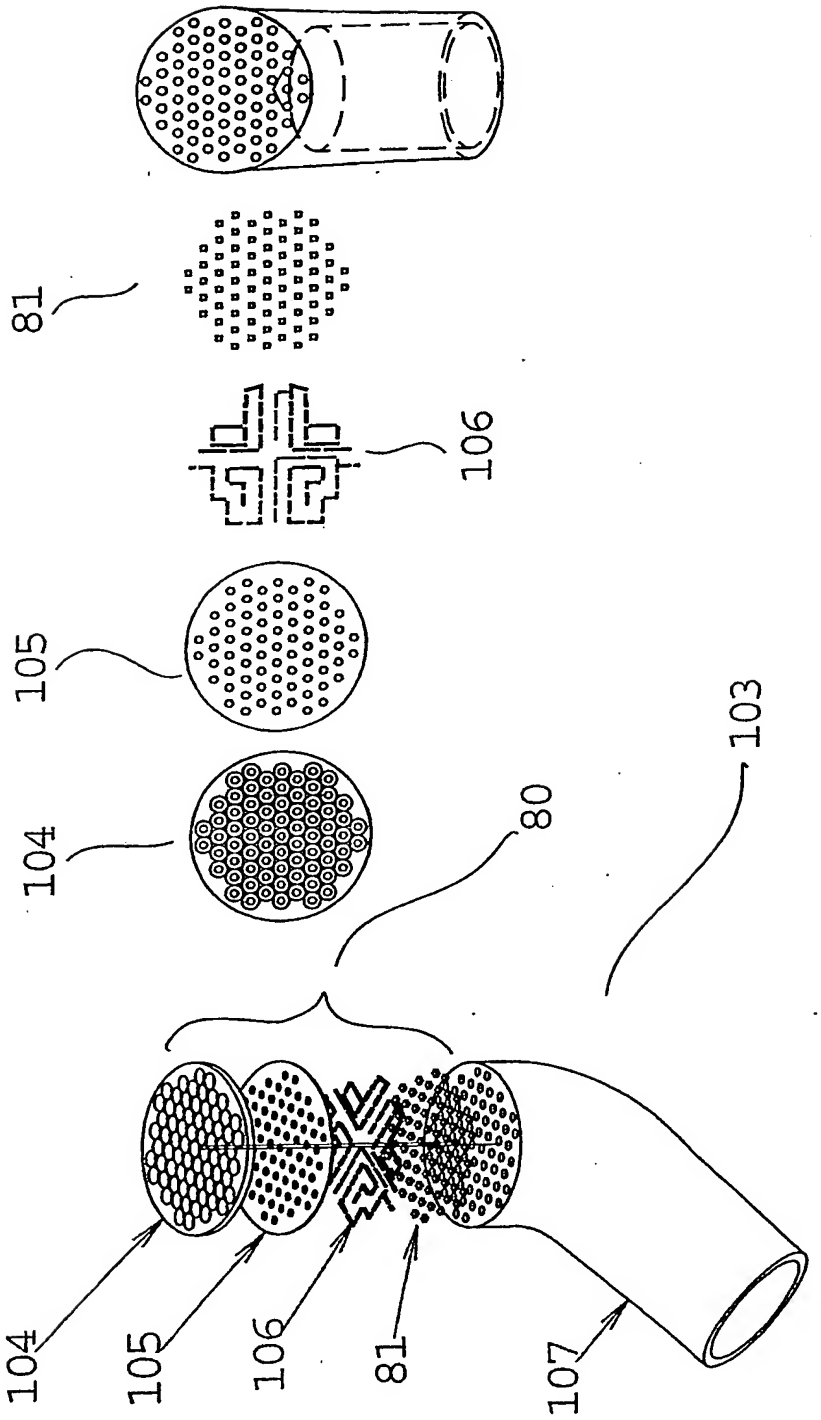


Fig. 9

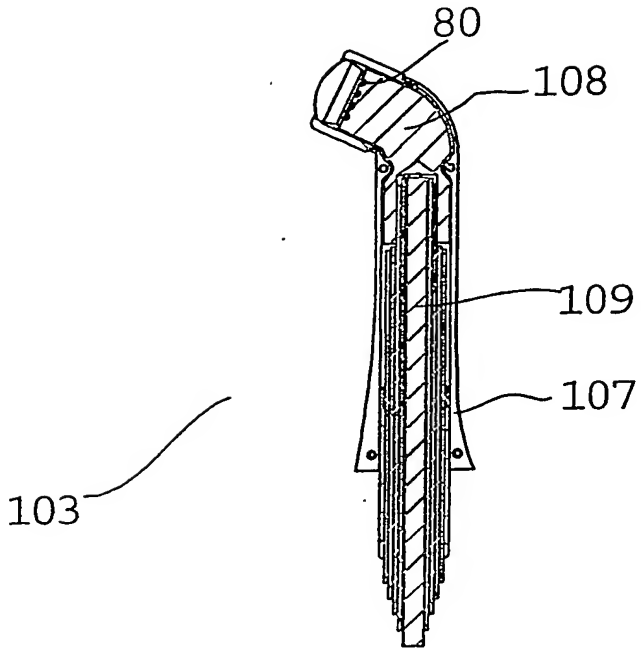


Fig. 10

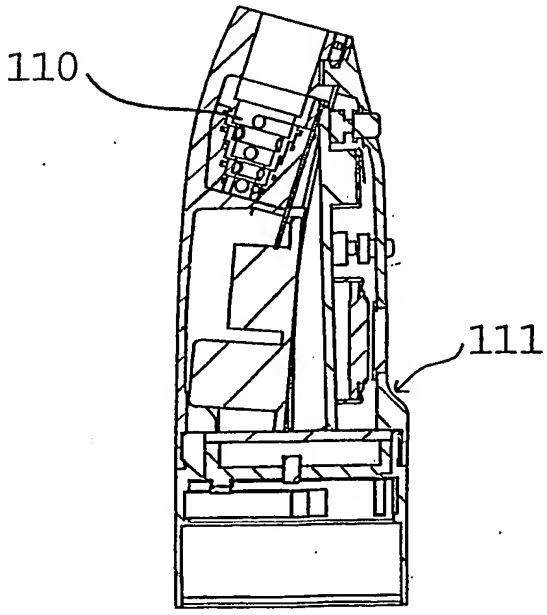


Fig. 11

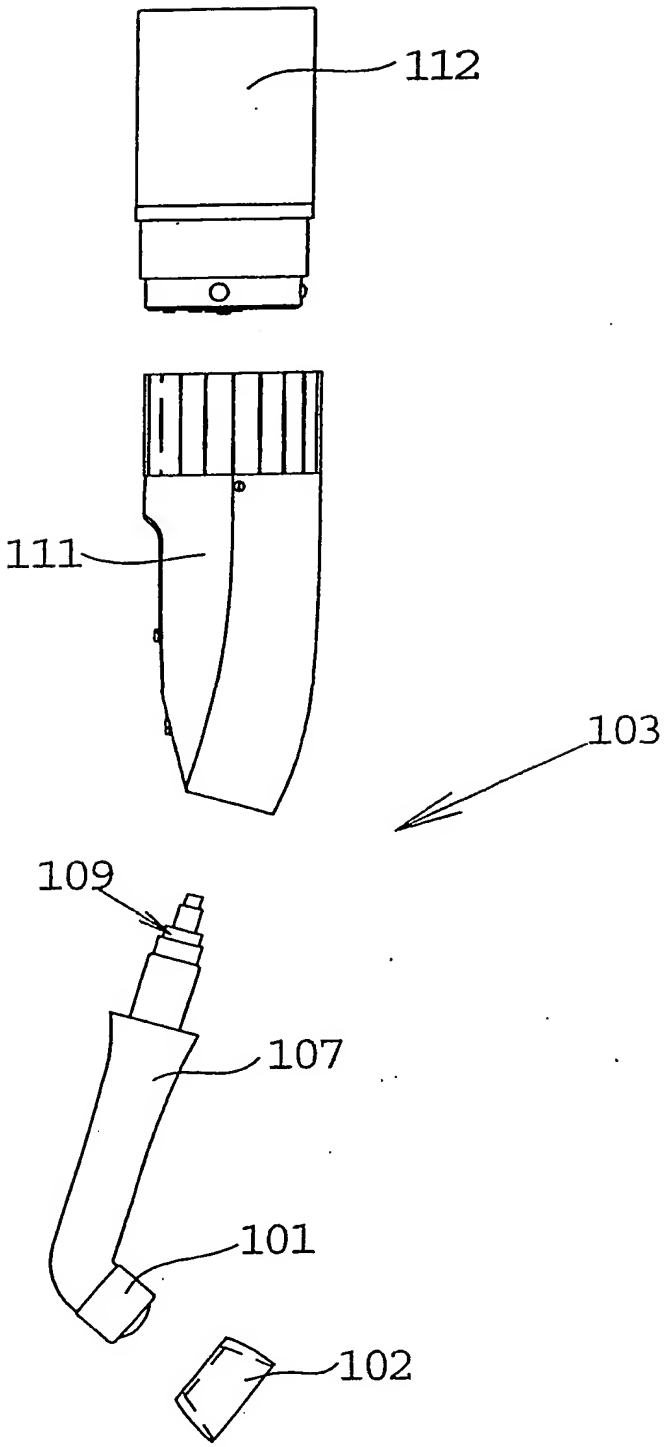


Fig. 12